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The Distribution and Abundance of the Chinese Mitten Crab (*Eriocheir sinensis*) in Santa Clara County, CA

A report for the Santa Clara Valley Water District

prepared by:

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The Distribution and Abundance of the Chinese Mitten Crab (*Eriocheir sinensis*) in Santa Clara County, CA

Summary:

Mitten crabs were found to be well-distributed in Santa Clara County, occuring in Coyote Creek, the Guadalupe River, San Tomas Aquino Creek, Calabazas Creek, Stevens Creek, Permanente Creek, San Francisquito Creek, Moffet Channel and Upper Penitencia Creek. Mitten crabs were most abundant and extended furthest inland on Coyote Creek and the Guadalupe River. Limited supplies of freshwater and concrete-lined flood control channels appeared to limit the present distribution of mitten crabs in Santa Clara County. Areas with vertical or near vertical banks had the highest density of crab burrows. Although bank slumping was observed in areas with high densities of mitten crabs, bank slumping was not very common and limited to certain areas. Control measures for mitten crabs do not appear necessary at this point in time, however monitoring of the populations and changes in channel conditions over time is highly suggested.

The Distribution and Abundance of the Chinese Mitten Crab (*Eriocheir sinensis*) in Santa Clara County, CA

Introduction:

The Chinese mitten crab (*Eriocheir sinensis*) is a freshwater grapsid crab in the sub-family Varuninae (Figure 1). Mitten crabs are native to coastal rivers and estuaries of Korea and China from the Yellow Sea to south of Shanghai (Cohen, 1995 and Panning, 1939). Grapsid crabs in this sub-family occur in marine, brackish, and freshwater habitats (Anger, 1995). The mitten crab, like other species of freshwater crabs in the sub-family Varuninae, is a catadromous species. Organisms that are catadromous grow and develop in freshwater, but must migrate to marine areas for reproduction and larval development. Although the first few months of a mitten crab's life is spent in sea water, most of its life is spent in freshwater areas. Mitten crabs have been known to migrate great distances upstream to freshwater areas in their native habitat. Mitten crabs have been found on the Yangtze River in China over 800 miles from the sea (Cohen, 1995). Juvenile development of mitten crabs in freshwater areas has been reported to take anywhere from 1-6 years (Panning, 1939).

Adult mitten crabs in China begin their migration to the sea during the late summer and early fall, mating in the outer estuaries during the winter (Anger, 1991) (Figure 2). Within 24 hours of mating, a female attaches the fertilized eggs to the pleopods on the underside of her abdomen (Panning, 1939). Adult female mitten crabs carry anywhere from 250,000 to 1,000,000 eggs (Cohen, 1995). Larvae hatch from these eggs during the spring and early summer. After five zoeal pelagic stages, larvae settle out as megalopae and begin their migration to freshwater areas during the summer (Anger, 1991).

Adult mitten crabs have an extremely wide range of physiological tolerances to different salinities. Schwabe (1933) was unable to measure any appreciable difference in oxygen consumption between mitten crab adults placed in fresh, brackish, and marine water. Being euryhaline is advantageous to adult mitten crabs because they must spend a considerable amount of time in a wide range of salinities, e.g. sea water as larvae, freshwater as juveniles, and sea water as adults.

When in tidally influenced areas, mitten crabs typically spend a large portion of their time in a burrow (Panning, 1939). Burrows are typically excavated into the sides of muddy river banks on a downward sloping angle, one crab to each burrow. During low tide, the burrows hold water protecting the mitten crabs from predators and desiccation. In China, mitten crabs and other freshwater crabs are often a nuisance as they burrow in rice paddies, eating young rice shoots (Ng, 1988).

Numerous problems were caused in European waterways by mitten crabs when the crabs were introduced into Europe at the turn of the century. Large numbers of burrows excavated by mitten crabs caused problems with bank erosion and levee damage in German rivers (Peters and Panning, 1933). Mitten crabs were also a nuisance to commercial fishermen by frequently filling fishing nets, damaging both the nets and the catch inside (Panning, 1939). The densities of mitten crabs became so high in some German Rivers that crabs would leave the water at night in search of new habitats or areas in which to forage (Panning, 1939).

The mitten crab can cause public health problems as well as ecological and economic problems. Almost all east Asian freshwater crabs, the mitten crab included, are intermediate hosts to lung flukes in the genus *Paragonimus*. (Ng, 1988). The mitten crab is the secondary host to the oriental lung fluke, *Paragonimus westermani*. Eggs of this parasite are released into the water from the waste products of humans and hatch into free-swimming larvae that penetrate the primary host, a freshwater snail (*Kellicotia*). The larvae then develop inside the snail, emerging as microcercous cercariae, crawling from the snail to the gills of a mitten crab (Ng, 1988). Humans that eat raw or partially cooked crabs become infected with the parasite when the cercariae penetrate the human duodenum and make their way to the lungs. Cercariae develop into adult flukes inside the lungs, attacking lung tissue and inducing a chronic cough. Flukes often make their way to other parts of the body such as the liver, eye tissues, and brain, causing great discomfort and sometimes death. Fortunately, at the present time, mitten crabs inhabiting San Francisco Bay are free of the lung fluke (Mark Torchen, UC-Santa Barbara, personal communication).

A Chinese mitten crab was first collected in South San Francisco Bay by a commercial shrimper during the winter of 1993 (Karen Grimmer, Marine Science Institute, personal communication). Soon after the initial discovery of a mitten crab in the South Bay, shrimping and research trawls began to collect more and more adult mitten crabs, including females with fertilized eggs. Numerous sightings of mitten crabs in the sloughs and creeks of South San Francisco Bay were reported by local citizens during 1995 and 1996. It was clear that mitten crabs were established in the South Bay however, the distribution, abundance, and activities of the crabs were not well known.

The goals of this study were to determine the distribution and abundance of juvenile mitten crabs in the sloughs and creeks of Santa Clara County and to determine the present threat of the mitten crabs to the integrity of levees lining the sloughs and creeks of Santa Clara County, CA.

Study site descriptions:

Surveys for mitten crabs were conducted at 66 sites in 18 tidal channels and freshwater tributaries of Santa Clara County, CA. The following tidal channels and creeks were sampled, Coyote Creek, Artesian Slough, Scott Creek, Penitencia Creek, Calera Creek, Berryessa Creek, Upper Penitencia Creek, the Guadalupe River, San Tomas Aquino Creek, Moffet Channel, Calabazas Creek, Permanente Creek, Stevens Creek, Adobe Creek, Hale Creek, Barron Creek, Matadero Creek, and San Francisquito Creek.

All of the sampled tidal channels and creeks were confined in some way by levees (of varying sizes and designs) extending inland from the river mouth. In areas near the bay, many of the west side creeks (Adobe Creek, San Francisquito Creek, Barron Creek, and Matadero Creek) were concrete lined flood control channels and provided no habitat for crabs. Most of the other channels however were lined with natural substrate and confined by set-back levees that allowed the river to occupy a portion of its flood plain. Leveed channels of this type did provide habitat for crabs (Figure 3).

Habitat conditions along the banks and sloughs changed dramatically from the river mouth to source. Areas near the bay were tidally influenced, receiving brackish water from the bay two times each day during high tides. As a result, the substrate lining the creeks and sloughs confined by set-back levees most often contained a high amount of clay that had been deposited from the Bay. Bank vegetation in these areas was usually dominated by one plant species, either alkali bulrush (*Scirpus robustus*) or pickleweed (*Salicornia*). Plants and animals living between the high and low tide lines in this area were subjected to water of variable salinity, and alternating dry and wet periods each day. Areas upstream that were not tidally influenced did not have these daily fluctuations in water levels and/or salinity.

The substrate of upstream areas was highly variable but often contained a mixture of mud, sand, and organic debris. In contrast to stream banks in sites near the bay, the banks of upstream areas were lined with many plant species. Most of the benthic organisms living in these areas had a low tolerance for water of varying salinity and were thus confined to upstream areas.

Methods:

Determination of mitten crab distribution in Santa Clara County

At each site examined, The presence or presumed absence of juvenile mitten crabs in an area was established by excavating burrows, setting crab traps, and visually inspecting the area for mitten crabs. Burrows were excavated by hand using shovels and spatulas. The rectangular crab traps were made from rubber-coated wire mesh and measured approximately 24" long x 6" wide x 6" high. Traps were baited with a can of "fish flavored" cat food and checked 24 hours after being set in the channel. Visual inspection entailed daytime searches for mitten crabs in the channel margins. Approximately one hour was spent at each site before deciding that mitten crabs were presumed to be absent from a site.

Abundance of mitten crabs in Santa Clara County

Different methods were used to estimate juvenile mitten crab abundance in tidally influenced and non-tidally influenced areas. The difference in methods was necessary because of the behavior of the crabs. In tidal areas, a crab spent most of its time in a burrow, always inhabiting the burrow during low tide. In non-tidal areas, a crab did not usually inhabit a burrow, rather the crab spent most of its time out in the open foraging for food. Thus, in tidal areas, burrow densities were used to estimate crab densities, and in non-tidal areas, baited traps were used to estimate relative abundance of mitten crabs between sites.

The densities of juvenile mitten crabs in tidal areas were estimated at four different sites during July 1996, the Guadalupe River at the Highway 237 bridge, the Guadalupe River at Tasman Rd., San Tomas Aquino Creek at the Highway 237 bridge, and Coyote Creek at Dixon Landing Rd. Relative abundances of juvenile mitten crabs were estimated at five non-tidal sites during July and August 1996, Hale Creek at Cuesta Rd., Coyote Creek at Julian Rd., the Guadalupe River at Trimble Rd., the Guadalupe River at Airport Rd., and Adobe Creek at East Bayshore Rd..

Mitten crab densities in tidal areas were estimated by counting the number of crab burrows within a specified area during low tide. Each burrow was not excavated to count the number of crabs because of the extensive damage such excavation would do to the streambanks. Thus, burrow density was used as a surrogate for mitten crab density, assuming one crab inhabits each burrow. Frequent estimates of burrow occupancy were made to ensure the adequacy of this approximation, burrow occupancy never fell below 80%. Given that mitten crabs could have occurred in these burrows but were not observed, this figure is likely an underestimate. Burrowing crayfish (the red swamp crayfish, *Procambarus clarkii*) that co-occur with mitten crabs constructed sufficiently different burrows so that crayfish burrows could be distinguished from mitten crab burrows.

Three randomly selected cross-stream transects were taken at each site to measure burrow densities in tidal areas. Sampling was always done during the lowest low tide of the day, with transects being made parallel to the stream channel along the exposed banks. Although the width of the transect varied, the length of the transect was always 5m. The width of the transect varied because width was always measured as the distance of bank from the water line to the high tide mark, a distance that varied with the height of the tide and the time of day when the transect was taken (Figure 4).

Baited traps were used in non-tidal areas to assess the relative abundance of juvenile mitten crabs between sites. Traps were of the same design as the traps used to estimate the presence/absence of crabs at a site. Traps were always checked 24 hours after being set in the channel.

Habitat parameters associated with mitten crabs in Santa Clara County

Habitat parameters associated with the presence and/or absence of mitten crabs were measured at most of the 66 survey sites. Data was not taken at most of the sites that were concrete lined flood control channels because they were often devoid of water. At each measured site, water temperature, salinity, bank substrate, and average water depth were recorded. Water temperature was measured in the shade with a thermometer and salinity was measured with a hydrometer. Average water depth was calculated as the mean of four measurements taken with a meter stick along a transect. Bank substrates were classified according to their predominant component: clay; mud; sand; organic debris; or gravel/cobble.

Attributes of mitten crab burrows & their potential impact on the levees of Santa Clara County

Levee damages attributable to mitten crab burrows were studied by estimating the volume of bank sediment removed by mitten crab burrowing. Burrow density (#/m^2) was estimated as described above and average burrow volume was estimated from average burrow lengths and widths measured at 150 mitten crab burrows from four different sites. To calculate burrow volume, each burrow was assumed to be a cylinder of uniform diameter (radius = 1/2 burrow entrance width, height = burrow length). Burrow width was measured with a ruler to the nearest cm. Burrow length was estimated by carefully excavating one side of the burrow and leaving the other side intact. A tape measure was laid along the intact half of the burrow (from the burrow entrance to the burrow end) to measure burrow length to the nearest cm.

Results:

Determination of mitten crab distribution in Santa Clara County

Mitten crabs were found at 30 of the 66 sites sampled in Santa Clara County, occurring up to 30 miles inland (Figure 5 and Appendix 1). Of the sampled sites, 18 sites were concrete lined channels, two were underground, and six were completely dry. Of the six completely dry channels, four were concrete lined and two were lined with natural substrate. Thus, only 44 of the 66 sites sampled were suitable habitat for crabs, and of these sites 30 contained mitten crabs.

Mitten crabs larger than 20 mm carapace width were never found in sloughs and creeks that became concrete lined channels less than one mile from the river mouth, i.e. San Francisquito Creek. All other tidal sites, except for San Francisquito Creek, contained crabs ranging in size from 5 - 35 mm carapace width. Because larger juveniles were not found upstream of the concrete lined areas along San Francisquito Creek, the lack of larger juveniles suggests that, in San Francisquito

Creek, either the older juveniles die or move back out into the Bay. Juveniles, like the adults, have the ability to tolerate a wide range of salinities (0 to 200% sea water) and could tolerate moving into the more saline waters of the Bay (Halat and Eastman, unpublished data).

No mitten crabs were found upstream of areas that were channelized and lined with concrete. Although it is possible that mitten crabs may eventually migrate upstream of the concrete lined areas into suitable habitats upstream, none were found during this survey in the summer of 1996.

Abundance of mitten crabs in Santa Clara County

Measured burrow densities at the four tidal sites ranged from 5 burrows/m^2 to 7 burrows/m^2. The Guadalupe River at Tasman Rd. site had the highest density of burrows (7/m2, std dev = 2). Burrow densities were similar between the three other tidal sites, the Guadalupe River at the Highway 237 bridge (5/m2, std dev = 2), San Tomas Aquino Creek at the Highway 237 bridge (5/m2, std dev = 1), and Coyote Creek at Dixon Landing Rd. (5/m2, std dev = 2).

Attempts to assess the relative abundance of mitten crabs between non-tidal sites were unsuccessful. Mitten crabs were not attracted to the baited traps placed in the creeks to measure presence/absence and abundance. Although numerous different types of bait were used in the traps, the traps proved to be unattractive to the crabs. Observation of crabs and traps in shallow water revealed that the crabs ignore the traps completely. Traps were very attractive however to red swamp crayfish. Observation of traps, crabs, and crayfish in shallow water revealed that crayfish move towards the traps and bait inside, whereas crabs ignore the traps. Visual counts of crab numbers in an area were also attempted, however this method was unsuccessful as well. Crabs usually took cover under objects along the streambed or quickly shuffled under the substrate when anyone approached the stream.

Habitat parameters associated with mitten crabs in Santa Clara County

Tidal sloughs and the lower reaches of freshwater creeks (i.e. areas closer to the bay) were inhabited by juvenile mitten crabs. Because mitten crabs take longer than one year to develop, juveniles could be found in both areas all year long. Juvenile mitten crabs inhabiting tidal sloughs were most common in areas of low salinity (<2-3 ppt.) that had steep, clay banks lined with alkali bulrush (*Scirpus robustus*) (Table 1). Water temperatures in these areas varied from 20-31°C during the summer of 1996 (Appendix 1).

Because juvenile mitten crabs move upstream to new areas during development, juveniles inhabiting the upper parts of freshwater creeks were older and larger than those inhabiting downstream and tidal areas. In freshwater creeks, juvenile mitten crabs were most abundant in shallow areas with slow moving water adjacent to deep pools with emergent macrophytes. Although mitten crabs were found upstream of riffles, no crabs were found inhabiting riffle areas.

Attributes of mitten crab burrows & their potential impact on the levees of Santa Clara County

The average diameter of a mitten crab burrow was 3 cm (n = 150, std dev = 1) and average depth of a burrow was 20 cm (n = 150, std dev = 12). Thus, the average volume of a burrow was 141 cm^3. Given this average burrow volume, bank sediment removal caused by mitten crab burrowing could be estimated in areas that had different densities of mitten crabs. Using the range of mitten crab densities found in the field ($5/m^2$ to $7/m^2$), sediment removal caused by crab burrowing was found to vary from 705 cm^3 to 987 cm^3 per m^2 bank area. This estimate is likely an underestimate as it does not include the secondary effect of increased erosion of banks weakened by burrows.

Discussion:

Discussion of Survey Results

The results of this survey indicate that mitten crabs are presently well-established in Santa Clara County, CA. The present distribution of the mitten crabs in Santa Clara County however appears to be confined by (1) a limited supply of freshwater during the summer and (2) the presence of concrete-lined flood control channels. Almost all of the freshwater areas that mitten crabs could inhabit (i.e. areas not lined with concrete) in Santa Clara County contain mitten crabs at this time. The crabs were most abundant and extended furthest upstream along the two largest tidal creeks in the county, the Guadalupe River and Coyote Creek. Upstream migration in many of the other channels was blocked by concrete or lack of available water.

Although densities of mitten crabs measured in tidal areas were quite low during July of 1996, densities the year prior were much higher along the Guadalupe River. Average burrow density along the Guadalupe River at the Highway 237 bridge during July of 1995 was 18 burrows/m^2 (std dev = 5). This decrease in burrow density is probably more of a reflection of sampling error than an actual decrease in the number of crabs. Areas of high mitten crab abundance are patchy and are most often limited to areas with vertical or near vertical banks. A channel cross-section of 5m in length will often cover areas of steep bank and areas of a much gentler gradient.

In Santa Clara County, mitten crabs typically excavated burrows in tidal areas only. Although crabs sometimes inhabit burrows in freshwater, non-tidal areas, the burrows are often on the stream bottom rather than along the stream banks. As a result, any damage to the stream banks should be confined to tidally influenced areas. The crabs that do burrow in tidal areas are typically less than 40 mm carapace width; larger crabs inhabit non-tidal areas and typically take cover under objects on the substrate or in deep pools. Although mainly the small crabs burrow, large numbers of small crab burrows have the potential to cause bank damage over time.

Burrows have the potential to damage banks and levees because burrowing removes sediment from the bank, weakening the overall structure of the bank. In addition, mitten crab burrows are designed to hold water in the burrow at low tide. Water retained within a burrow increases the pore pressure on the banks, increasing the potential for bank slumping. Mitten crab burrows, by removing sediment and increasing pore pressure on the banks, make bank areas more susceptible to natural erosive forces (rain and tidal events).

Bank slumping was observed in areas with high numbers of mitten crabs along the Guadalupe River and Coyote Creek. Bank slumping was observed to occur only in areas with vertical or near vertical banks. The pieces of bank that had slumped off usually contained numerous burrows and crabs. These pieces of "slumped-off bank" often altered the morphology of the bank, changing the bank from a near vertical wall to one with a reduced slope. Much sediment deposition occurs along bank areas with reduced slope during the summer. Crab burrows on sloped banks are often covered up with deposited sediment during the summer. When this occurs, burrows are abandoned by the crabs. It is possible that bank slumping in areas with numerous crab burrows may, over time, alter the bank structure, making the banks less suitable for crab burrowing.

Most of the tidal channels into which the mitten crabs are now burrowing are set-back leveed channels. The distance between the levees and area where the crabs are burrowing in these channels is often ten meters or more. Over time, extensive burrowing and erosion could reduce this distance and eventually threaten the levees. At this point in time however, no mitten crabs have been observed to be burrowing into the actual levees.

Suggestions for Future Management and Monitoring

The mitten crab is presently well-established in Santa Clara County and is now likely a permanent resident of the tidal channels and creeks in this area. It is not known at this point in time what the impact of this crab will be, both economically and ecologically. Economic damage to levees by mitten crab burrowing will vary depending on the density of mitten crabs, the type of levee, and suitability of the area for crab burrowing. Monitoring crab numbers on a yearly basis, documenting areas of bank slumping, and monitoring changes in channel width will provide good baseline data against which to measure changes in channel conditions over time.

Control of mitten crab numbers by an existing South Bay predator is not likely at this time. Predator control of the population is not likely because no South Bay predator specializes on mitten crabs and because the crabs are so abundant. If population numbers continue to increase in the tidal channels and sloughs of Santa Clara County, the crabs will most likely become a nuisance to local citizens and fishermen before causing levees to weaken. Regardless of the reason for control measures, control measures for mitten crabs do not seem necessary at this time. Although densities of crabs are high in some areas, the amount of bank slumping in areas with mitten crabs was quite small and was very patchy. If bank slumping does become a problem, Coyote Creek, the Guadalupe River, and San Tomas Aquino will most likely be the areas affected. These creeks presently have the highest densities of mitten crabs in the area.

Conclusion:

No present control measures are suggested for mitten crabs in Santa Clara County. Although the crabs are well-distributed in the county and very dense in some locations, no large amount of bank damage caused or influenced by the presence of mitten crabs was seen during the summer of 1996. Monitoring the problem however is strongly recommended. Damage to the streambanks will not be an overnight phenomenon, rather it will be the accumulation of past years of burrowing activity. Thus, it is necessary to monitor both crab numbers and channel conditions on a yearly basis.

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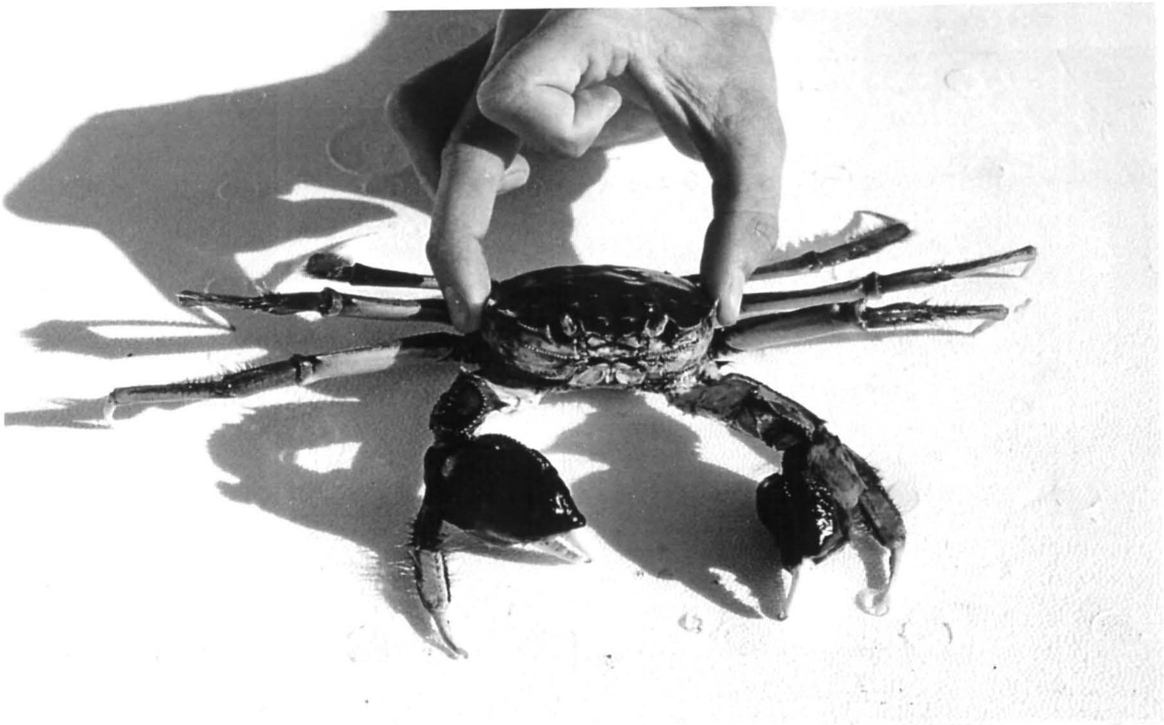

Figure 1. Adult male mitten crab collected from the mouth of Coyote Creek (carapace width of the crab is approximately 80 mm).

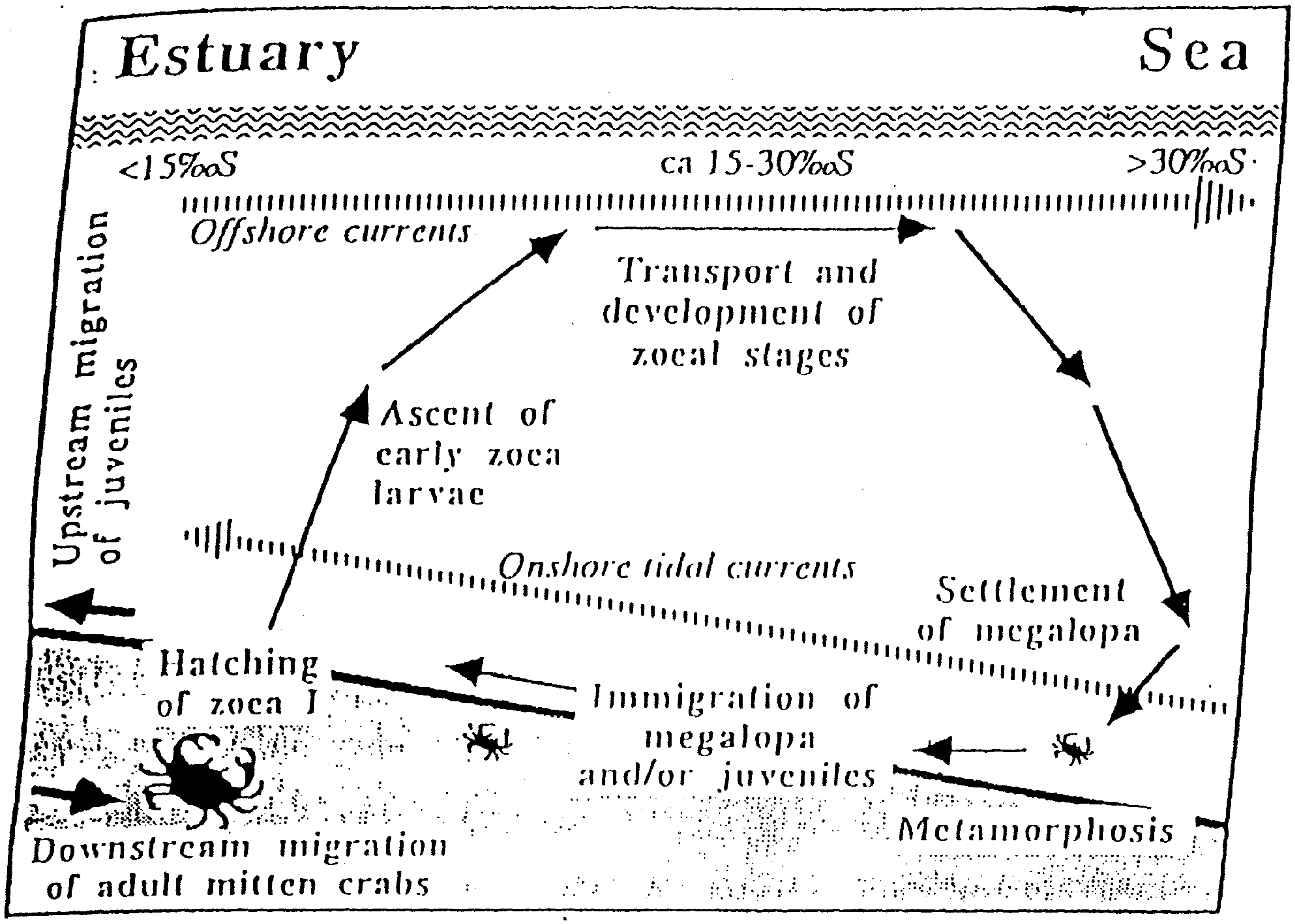
Estuary
Sea
<15‰S
ca 15-30‰S
>30‰S
Offshore currents
Transport and development of zoeal stages
Ascent of early zoea larvae
Upstream migration of juveniles
Onshore tidal currents
Settlement of megalopa
Hatching of zoea I
Immigration of megalopa and/or juveniles
Metamorphosis
Downstream migration of adult mitten crabs

Figure 2. Life cycle of the mitten crab (Anger, 1991).

SET-BACK LEVEE CHANNEL

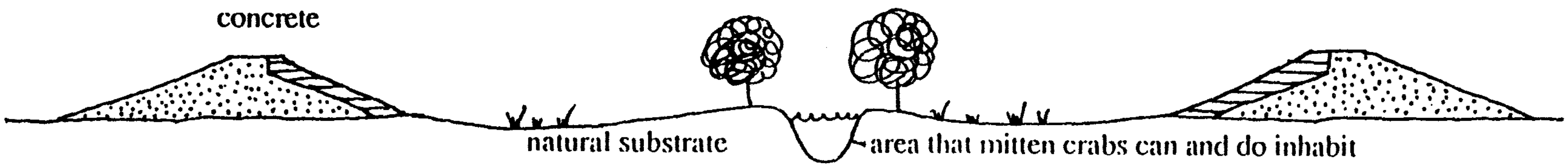

Figure 3. Set-back levee channel design and the area of the channel that crabs inhabit (adapted from Mount, 1995).

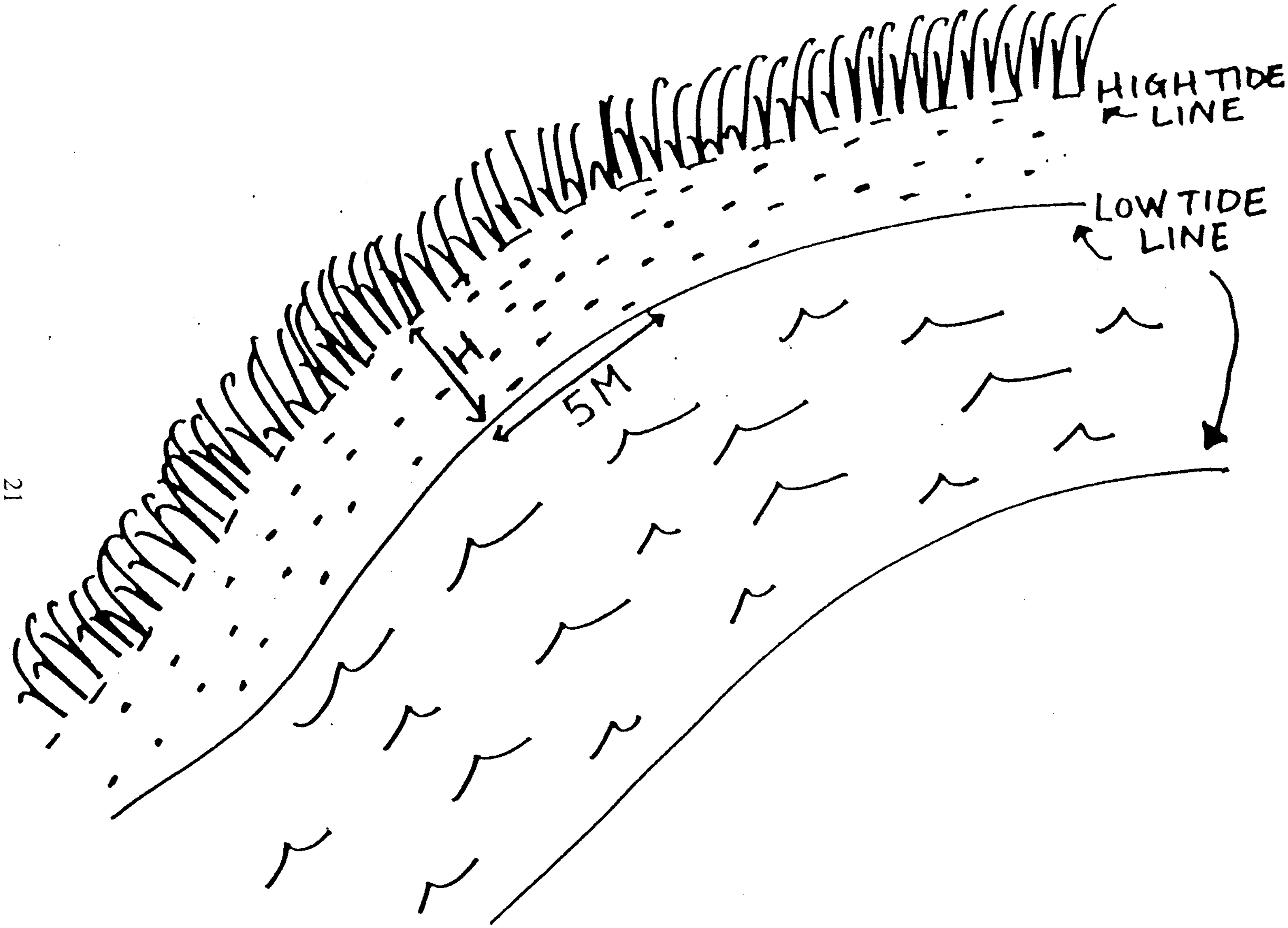

Figure 4. Schematic representation of a typical channel cross-section used to estimate mitten crab burrow density (H indicates the height of the transect and 5m is the standard length).

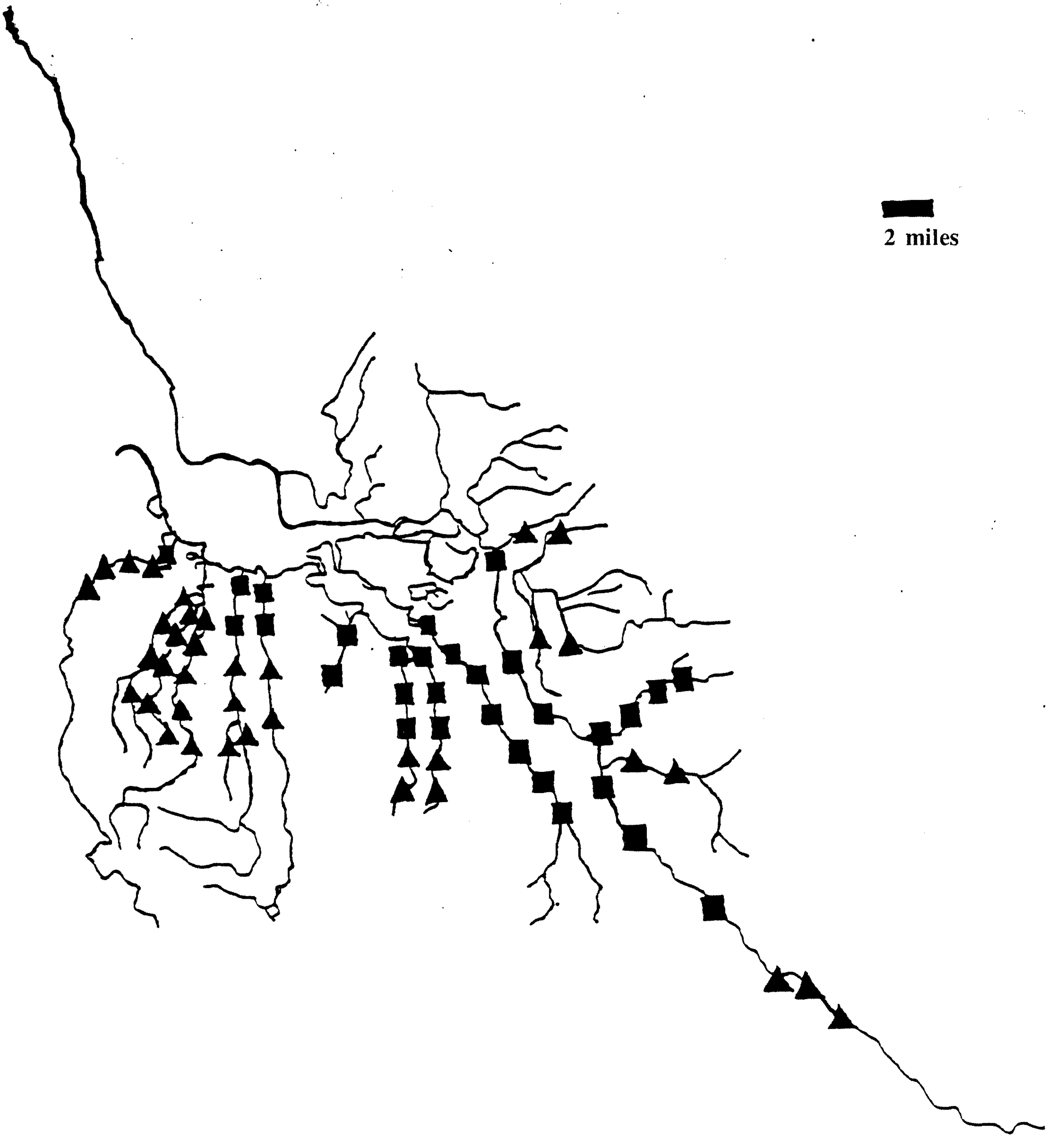

Figure 5. Distribution of juvenile mitten crabs in Santa Clara County during the summer of 1996. Squares indicate sites where mitten crabs were present and triangles indicate sites where mitten crabs were absent.

Table 1. Range of habitats across which juvenile mitten crabs occur in Santa Clara County, CA.

	Least common:	Most common:
Salinity	15 ppt	0 ppt
Bank substrate	mud/sand	clay
Bank morphology	steep banks	sloped banks
Bank vegetation	dominated by alkali bulrush	large number of riparian plant species

APPENDIX 1. June and July 1996 mitten crab survey data.

Site #	Site location	Mitten crab status (no=0, yes=1)	Temp (C)	Salinity ppt	Water Depth	Substrate
1	Guadalupe River at Highway 237	1	.	0	>1m	clay
2	Guadalupe River at Tasman Rd	1	.	0	>1m	clay/gravel
3	Guadalupe River at Montague Expwy	1	.	0	>1m	mud
4	Guadalupe River at Trimble Rd	1	.	0	0.05m-0.3m	sand/mud//cobble
5	Guadalupe River at Airport Rd	1	23.5	0	0.05m-0.3m	sand/cobble
6	Guadalupe River at Taylor St	1	22	0	0.05m-0.3m	sand/cobble
7	Guadalupe River at San Fernando Rd	1	23	0	0.05m-1m	sand/cobble
8	San Francisquito Ck at E. Bayshore Rd	1	26.5	1.006	0.05-0.1m	clay
9	San Francisquito Ck at Newell Rd	0	18	1.001	pools of 0.05m-0.1m	sand/cobble
10	San Francisquito Ck at University Ave	0	.	.	0	sand/cobble
11	San Francisquito Ck at Chaucer Rd	0	21	0	0.05-0.1m	sand/cobble
12	San Francisquito Ck at El Camino Real	0	20.5	0	0.05m-0.3m	sand/cobble
13	Matadero Ck at E. Bayshore Rd	0	20	0	.	concrete/mud
14	Matadero Ck at Middlefield Rd	0	.	.	>1m	concrete
15	Matadero Ck at Alma Rd	0	.	.	.	concrete
16	Matadero Ck at El Camino Real	0	.	.	0.05m	concrete
17	Adobe Ck at E. Bayshore Rd	0	22	0	0.05m-0.3m	concrete/mud
18	Adobe Ck at Louis Rd	0	.	.	0.05m-0.3m	concrete/mud
19	Adobe Ck at Middlefield Rd	0	.	.	.	concrete
20	Adobe Ck at Alma Rd	0	.	.	0.05m	concrete
21	Adobe Ck at El Camino Real	0	.	.	0	concrete
22	Barron Ck at E. Bayshore Rd	0	.	.	.	underground
23	Barron Ck at Louis Rd	0	.	.	0.05-0.1m	concrete
24	Barron Ck at Middlefield Rd	0	.	.	.	concrete
25	Barron Ck at Alma Rd	0	.	.	.	concrete
26	Barron Ck at El Camino Real	0	.	.	.	concrete
27	Permanente Ck at N. Shoreline Blvd	1	26	1.001	0.7m-1m	clay
28	Permanente Ck at Amphitheatre Dr	1	31	0	0.3-0.7m	mud
29	Permanente Ck at Middlefield Rd	0	.	.	0.05m	concrete
30	Permanente Ck at El Camino Real	0	.	.	.	underground
31	Permanente Ck at Cuesta Rd	0	21	0	0.3-0.7m	mud/cobble

32	Hale Ck at Cuesta Rd	0	.	.	0	concrete
33	Stevens Ck at Crittenden Dr	1	25.5	0	0.3-1m	clay
34	Stevens Ck at Moffet Blvd	1	24	0	0.3-0.7m	mud
35	Stevens Ck at Dana Rd	0	.	.	0	cobble
36	Stevens Ck at El Camino Real	0	.	.	0	concrete/boulder
37	Moffet Channel at Mathilda Ave	1	28	0	0.05m-0.3m	mud
38	Moffet Channel at Carribean Dr	1	26	0	0.3-0.7m	mud
39	San Tomas Aquino Ck at Moffet Park Blvd	1	.	.	.	.
40	San Tomas Aquino Ck at Tasman Rd	1	.	.	.	.
41	San Tomas Aquino Ck at Mission College Dr	1	29	0	0.1-0.3m	cobble/sand
42	San Tomas Aquino Ck at Kifer Rd	0	28	0	almost none	cobble/sand
43	San Tomas Aquino Ck at El Camino Real	0	26	0	pools of 0.05m-0.1m	cobble
44	Calabazas Ck at Moffet Park Blvd	1	.	.	>1m	mud
45	Calabazas Ck at Tasman Rd	1	.	.	>1m	.
46	Calabazas Ck at Mission College Dr	1	27	0	.	mud/cobble
47	Calabazas Ck at Kifer Rd	0	.	.	0.05-0.1m	concrete
48	Calabazas Ck at El Camino Real	0	.	.	0.05m	concrete
49	Coyote Ck at Dixon Landing Rd	1	23	.	0.1m-1m	mud/clay
50	Coyote Ck at Charcot Ave	1	20.5	0	0.3m	sand/gravel
51	Coyote Ck at Berryessa Rd	1	22	0	0.3m	silty
52	Coyote Ck at Julian Rd	1	21	0	0.1m-0.7m	silty
53	Coyote Ck at Story Rd	1	21.5	0	>1m	silty/cobble
54	Coyote Ck at Yerba Buena Rd	1	25.5	0	0.3m	silty/cobble
55	Coyote Ck at Silver Valley Rd	0	23	0	0.3m-1m	mud/gravel
56	Coyote Ck	0	25	0	.	silt/boulders
57	Coyote Ck at Coyote Ranch Rd	0	21	0	0.3m	silt/boulders
58	Upper Pennitencia Ck at Maybury Rd	1	23	0	0.1m	sand/cobble
59	Upper Pennitencia Ck at N. Capitol Rd	1	22	0	0.1m-0.3m	sand/cobble
60	Upper Pennitencia Ck at Piedmont Rd	1	23	0	0.3m	silt/sand/cobble
61	Upper Pennitencia Ck at Dorel Dr	1	22	0	0.1m-0.5m	silt/cobble
62	unnamed Coyote Ck tributary at King Rd	0	28	0	0.1m-0.3m	mud
63	unnamed Coyote Ck tributary at San Antonio Rd	0	28	0	0.3m	silt/cobble
64	Scott Ck at N. Milpitas Rd	0	.	.	0.05m	concrete
65	Calera Ck at Arizona Rd	0	20.5	0	0.1m	silt
66	Pennitencia Ck at Abel Rd	0	22.5	0	0.3m-0.7m	silt
67	Berryessa Ck	0	.	.	0	gravel